Measurement of the Parity-Violating Gamma Asymmetry in the Capture of Polarized Cold Neutrons by Para-Hydrogen

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The weak interaction between nucleons is mediated through the exchange of $W^{\pm}$ and Z^0 bosons between quarks. The range of the weak force is short when compared to the nucleon-nucleon separation in the nucleus and the weak nucleon-nucleon interaction may be represented by a meson exchange potential. In particular, the parity violating nucleon-nucleon observables can be described in terms of the weak meson-nucleon-nucleon coupling constants: H_π^1, H_ρ^0, H_ρ^1, H_ρ^2, $H_\rho'^1$, H_ω^0, and H_ω^1, which corresponds to the exchange of π, ρ, and ω mesons. An important parity violating observable is the gamma ray asymmetry, A_γ, with respect to the neutron spin in capture of cold polarized neutrons on para-hydrogen: $\vec{n} + p \rightarrow d + \gamma$. The asymmetry, A_γ, is directly related to the weak meson-nucleon-nucleon couplings by:

$$A_\gamma = -0.045 H_\pi^1 + 0.001 H_\rho^1 - 0.001 H_\omega^1 - 0.002 H_\rho'^1$$

where the coefficients are well known. Note that the asymmetry is dominated by H_π^1 and a measurement of A_γ is essentially a measurement of H_π^1. The best theoretical values for the weak meson-nucleon-nucleon coupling constants predict the value of the asymmetry of the order: $A_\gamma \sim 5 \times 10^{-8}$ [1]. Previous measurements of H_π^1 in ^{18}F and other systems have resulted in very different values [2,3] but a precise determination of H_π^1 from the asymmetry A_γ will resolve this issue. The goal of the NPDGamma experiment*†[4] is to measure the asymmetry, A_γ, to better than 0.5×10^{-8} at the Los Alamos Neutron Science Center (LANSCE). Neutrons from the LANSCE spallation target are thermalized with a liquid hydrogen moderator and guided to the experimental apparatus shown in Fig. 1. The experimental apparatus consists of a ^{3}He neutron spin filter, a RF neutron spin flipper, a liquid hydrogen target, and a CsI detector array that is used to detect the 2.2 MeV gamma ray from neutron capture. The NPDGamma experiment had a successful test run in Oct. 2000 where the gamma ray asymmetry from polarized neutron capture on ^{35}Cl was measured. This parity violating asymmetry is large [5] and can be used as a test of the detector. The NPDGamma experiment is expected to begin running in early 2003.

Footnotes and References

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† http://p23.lanl.gov/len/npdg/

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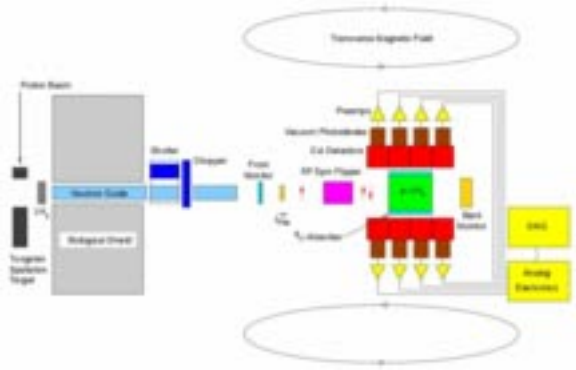

Fig. 1. Layout of the NPDGamma experiment.